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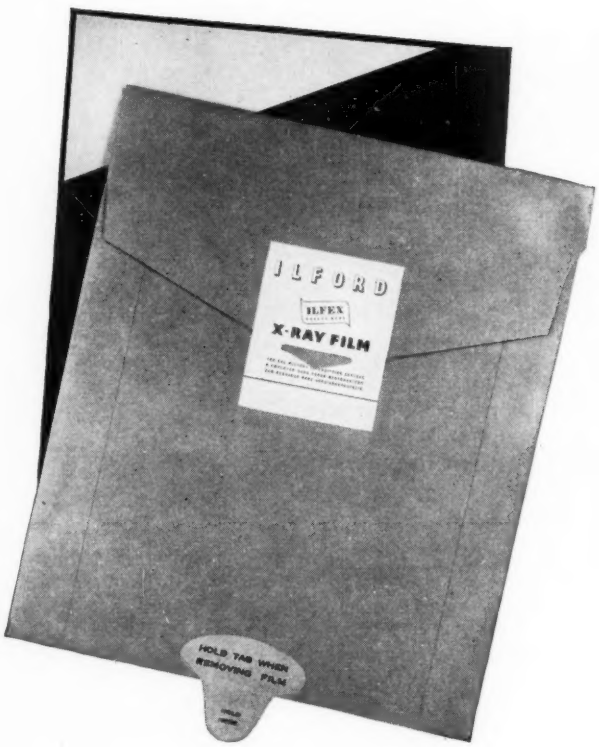

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THE JOURNAL OF THE
CANADIAN ASSOCIATION OF RADIOLOGISTS

Volume VII December 1956 Number 4

ANEURYSMAL BONE CYST*

ROLAND GUY, M.D., ODILON RAYMOND, M.D., ROGER SAMSON, M.D.
and J. EDOUARD SAMSON, M.D.

Montreal, Quebec

Lichtenstein[1] defines the aneurysmal bone cyst as a pathologic entity of bone, characterized by a solitary, localized, distended and lacunar lesion. The latter characteristics are explained by the presence of a greatly dilated and plexiform vascular bed. The lesion develops in the spine, the flat bones, and the shaft of long bones. This definition of aneurysmal bone cyst may at first appear ambiguous, especially if one's attention lingers on the adjective aneurysmal. However Jaffe[2] emphasizes the fact that the adjective aneurysmal must be interpreted in its broad and etymological meaning, expressing simply the distention or the swelling of the lesion without necessarily implicating the true existence of a complex vascular connection. As for the use of the term cyst, it is commendable because when cutting the shell of this pseudotumour, one is in the presence of polycystic tissue formation where lacunae, bordered by soft tissue, are filled with circulating blood.

In 1943, Jaffe and Lichtenstein[3], in a retrospective study of the solitary bone cyst, mentioned two peculiar cases which they considered as representing a different pathologic bone entity and for which they suggested the term aneurysmal bone cyst. Formerly, Ewing[4] had used this term when discussing identical lesions although he did consider them to be giant cell tumours modified by the presence of connecting blood vessels. Before Jaffe and Lichtenstein's contributions, a few authors had described similar lesions but had considered them to be osteitis fibrosa cystica,[5,6] hemorrhagic osteomyelitis,[7] ossifying hematoma[8,9], parosteal callus[10], tumour of blood vessels,[11] atypical,[12,13,14] pulsating,[15] or subperiosteal giant cell tumour.[16] From 1942 to 1950, only Mayer and Kestler [17] made use of the terminology proposed by Jaffe and Lichtenstein. The authors of other publications,[18,19,20,21,22,23,24] written during the same interval, considered the aneurysmal bone cyst as a giant cell tumour. However, all reporters are impressed by its atypical subperiosteal localization and its characteristic benignity. Geschickter and Copeland[25] even contend that the aneurysmal bone cyst is a tumour similar to osteitis fibrosa and giant cell tumour. Coley,[21] although considering the lesion as a giant cell tumour is conscious that this diagnosis is not absolute and emphasizes its atypical features. Most of the aneurysmal bone cysts are reported during the period 1950-1955 by Jaffe,[2] Lichtenstein,[1,26] Thompson,[27] Dahlin et al,[28] and by Besse and his colleagues,[29] There are approximately 108 aneurysmal bone cysts, published to date, chiefly in the American literature. While this paper was being written, the British authors[30,31] reported their first 8 cases. Because of our interest in the recent publications on the subject we have reviewed some benign tumours classified in our collection for many years under other terminology. We have found two cases which may be reclassified as aneurysmal bone cysts on the basis of their clinical, radiological and pathological features. The second case has been reported by one of us.[32] We have reviewed the literature briefly with particular reference to the characteristic features of this bone lesion.

Translation of paper presented at meeting of Société Canadienne Française d'Electroradiologie Médicale, Montreal, April 14, 1956.

Case 1

R.M., male, age 15 years, admitted to hospital on December 31, 1940, for a painful swelling in the right inguinal region with a tentative diagnosis of acute osteomyelitis. He gave a vague history of trauma which had occurred a month previously. The onset of the present condition dated back to December 10th with intermittent pains in the right groin. The patient remained active but had to be given analgesics. The swelling appeared on December 15th and quickly grew to such an extent that the leg became weak and the patient had to remain in bed. The pain was very severe even at rest.

Examination on admission: Right hip — flexion 150 degrees with abduction of 15 degrees. The leg was externally rotated and the thigh muscles were in spasm. The large mass in the medial region of the right groin felt firm but slightly resilient to palpation. The skin was tightly stretched over the mass but there was no redness. Palpation of the tumour caused pain but the hip joint appeared to be normal on examination.

X-ray examination on admission revealed an irregular increase of the density of soft tissues just below the horizontal ramus of the pubis. No calcific deposit identified in this region. The bony structure of the pubic ramus and the hip joint appeared normal. (Fig. 1.)

A punch biopsy made a few days later yielded only blood. A surgical biopsy was done on January 24, 1941. The biopsy obtained from the bony shell of the tumour contained brownish, slightly hemorrhagic and granular tissue. The histological diagnosis made at that time was ossifying fibroma.

An X-ray taken on February 17, 1941, showed a large mass at the inferior border of the horizontal ramus of the right pubis, extending from the medial border of the femoral neck as far as the midline. (Fig. 2.)

The mass measured about 10 x 6 cm. and was attached by a broad base of approximately 4 cm. in width. This lobulated mass was encapsulated by a thin calcified shell. Bony trabeculae were seen traversing the mass which was thus divided into multiple small spaces showing areas of decreased density giving it a honeycomb appearance. It was not possible to show any structural changes in the bone of the pubis probably due to the overlapping of the ischium and the superior ramus of the pubic bone. On March 11, 1941, the tumour was resected "in toto" with the superior ramus of the pubic bone. At operation it was found that the mass was located under the abductor muscles from which it was easily removed. The tumour was encapsulated, had a hard consistency and was irregularly lobulated. It was implanted on the anterior surface of the superior ramus of the pubic bone, obstructing the obturator foramen.

At present the patient is well and does not have any pain in his limb. There has been no recurrence of the tumour. Movements of the hip are complete and painless.

Case 2

P.B., female, age 5 years, was admitted to hospital on July 8, 1948, for a painful swelling in the lower back. The patient had been in good health until February 1948 when she began to complain of occasional backache. There was no history of trauma. A few days later the parents noted a swelling in the lower back and the patient complained of pain in her right leg. The mass grew

Fig. 1 Case 1. X-ray on admission showing irregular dense shadows in the soft tissues below horizontal ramus of pubis.

Fig. 2. Case 1. X-ray 7 weeks later showing radiolucent mass with bony trabeculae and thin calcified shell.

Fig. 3 Case 1. Subperiosteal new bone formation at periphery of lesion, adhering to a thick fibrous lamella at lower right. Degeneration and sclerosis of striated muscle fibres. (X 90.)

Fig. 4. Case 1. Cavernous vascular channels without demonstrable lining, showing non-coagulated blood. (X 26.)

rapidly and the patient began to drag the right foot as she walked. Examination on admission revealed a thin child who appeared to have lost some weight. She cried constantly because of pain. She could not lie on her back because of a large mass in the lower lumbar region; she preferred to lie on her left side with knees and hips flexed. The lumbar mass which measured approximately seven to eight centimeters was lumpy, bony hard, and located slightly to the right of the midline. The skin and subcutaneous tissues were free and there was no local heat; the right iliac fossa was tender to palpation. The right leg was atrophied, the foot and toes plantar flexed. There was little, if any, active plantar flexion and no active dorsiflexion of the toes on the right side. There was some weakness of the quadriceps. The ankle jerk and plantar reflexes were absent on the right side. Sensation was slightly diminished on the posterior aspect of the leg and foot.

The blood count was normal with a hemoglobin of 90% and a slight leucocytosis.

X-rays at that time showed a left lumbar scoliosis of 15 degrees. To the right of the lumbar spine and above the right iliac wing there was a mass measuring approximately 6 cm. in diameter.

Fig. 5 Case 2. X-ray showing thin bone shell at periphery, and bony trabeculae. The soap bubble appearance is characteristic of aneurysmal bone cyst.

This mass was lobulated and lined by a thin bony shell with a coarse "soap bubble" pattern. It extended slightly in front of the right iliac wing which appeared decalcified in the region of the sacro-iliac joint. There was complete destruction of the right transverse process, the right lamina and articular processes, and the right half of the body of the 5th lumbar vertebra. There was invasion also of the first sacral vertebra (Fig. 5.) On July 20th, a trocar was introduced under local anaesthesia. After piercing a thin bony shell, 50 cc. of blood was aspirated without tissue fragments. A few days later the patient was operated upon. The operation report reads: "The tumour is lobulated and measures approximately 8 cm. in its greater diameter. Its colour is dark brown and it is limited by a thin shell. It is strongly adherent to the internal wall of the minor pelvis as well as the radicles of the fourth and fifth right lumbar vertebrae. The tumour is pediculated to the lamina of the fifth lumbar vertebra which it destroys. During dissection the shell is ruptured, thus causing a rather extensive hemorrhage."

The greater part of the tumour was then curetted, leaving behind part of the wall of the cyst.

The histological diagnosis made at that time on the curettings was ossifying giant cell tumour. The patient is now in good health and there has been no recurrence of the lesion.

CLINICAL CONSIDERATIONS

Incidence:

It is rather difficult to compute with exactness the general incidence of the aneurysmal bone cyst, if one has in mind the number of terms describing this lesion. In the paper of Dahlin et al from the Mayo Clinic, an extensive work which we have already cited, there is reported an incidence of 1.3% in a total of 2000 bone lesions observed during a period extending from 1905 to 1952. Barely 25% of the cases published so far have been reported previous to the contributions of Jaffe and Lichtenstein written in 1950. These authors reported respectively on 20 and 17 cases. It seems worthwhile to mention that the same authors had reported but two cases in 1942. One therefore gains the impression that the lesion may be encountered more frequently than is indicated by reference to the literature.

Localization:

Table 1 shows the skeletal distribution of 79 cases of aneurysmal bone cyst reported by some of the authors already mentioned.

TABLE I

Lower Extremity		Upper Extremity		Spine		Thorax		Cranium and Face	
Innominate bone	5	Clavicle	1	Vertebrae	21	Ribs	2	Occipital Bone	2
Femur	11	Scapula	1			Sternum	1	Inferior Maxilla	1
Tibia	12	Humerus	8						
Fibula	5	Ulna	5						
Foot Bones	3	Radius	1						
Total	36		16		21		3		3

TABLE II

AGE INCIDENCE OF ANEURYSMAL BONE CYST

Age	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-
Number of Cases	1	10	11	23	10	4	3	2	2

Most aneurysmal bone cysts are located in the long bones and the vertebrae. A little less than half of the total are situated in the lower limb. Involvement of the upper limb is only about half as frequent. The femur and the tibia are the long bones most frequently involved. The lesion is less frequently seen in the fibula, innominate bone and the tarsal bones.

In the upper extremity the condition is most frequently encountered in the humerus and the ulna. Aneurysmal bone cyst is rarely seen elsewhere in the arm. No case has been reported in the carpal bones, metacarpal bones or phalanges. One is impressed by the frequent occurrence in the vertebrae, the incidence being about 25% of all cases. However the lesion does not show any predilection for any particular part of the spine.

In our two personal observations, one aneurysmal bone cyst was situated in a vertebra while the second was located in the pubic bone, a rare site. It is interesting to note that of the first two cases reported by Jaffe and Lichtenstein (1942), one presented a lesion located in a pubic bone.

Age:

In Table II we have analyzed the age incidence of 66 cases of aneurysmal bone cyst as reported in the literature. It is noted that two-thirds of the subjects are less than 20 years of age.

The average age is 17.9 years, approximately the same as reported by Dahlin et al.[28] Jaffe[2] and Lichtenstein[1] had previously emphasized the fact that the aneurysmal bone cyst is encountered mostly in older children, adolescents and young adults.

Sex:

Analysis of 68 cases of aneurysmal bone cyst, where the sex has been noted by the reporters, shows that 39 patients were males and 29 females.

The apparent predilection for the male sex has no absolute value. Jaffe and more recently Dahlin et al have found more female cases, while Lichtenstein and Thompson have reported a predilection for the male sex. Therefore, there appears to be no true predominance of either sex. Lichtenstein himself, in a personal communication to the reporters of the Mayo Clinic, agrees that he has not found a predominance of either sex.

In our own observations one patient was a girl and the other a boy.

Duration of Symptoms:

We have studied the duration of symptoms from the onset of the disease to the first consultation in 58 cases. The average duration was three months. The shortest duration was 2 weeks and the longest, 3 years. In our own cases the duration of symptoms was 3 weeks in the first case and 4 months in the second.

Trauma:

There had been a positive history of trauma in 26 out of 55 cases in which this factor was considered.

Most authors do not believe in a direct relationship between trauma and the lesion. It is important to recognize the fact that in 50% of cases there is no positive history of trauma. However Geschickter and Copeland[22] express the opinion that the lesion is definitely related to trauma, as does Thompson.[27] Mary S. Sherman, discussing Thompson's presentation, states that in her opinion it is hardly conceivable that a direct relationship exists between the lesion and the trauma if one bears in mind that the aneurysmal bone cyst is a rather rare lesion while the number of traumata involving the periosteum is innumerable.

Jaffe[2] considers the fact that the trauma may be the initiating factor. He adds that although a positive history of trauma is elicited, it is probable that the latter simply draws attention to the lesion by bringing about an exacerbation.

In one of our cases there was a history of trauma.

Symptomatology

The symptoms vary according to the localization. When the lesion is located in a long bone the patient will complain of a slight persistent pain of a few weeks' duration. He will then notice a bony hard swelling. Once the lesion is apparent the evolution is very rapid. Shortly the tumour will reach a noticeable size. If it is close to a joint it will rapidly cause loss of strength. Exercise usually causes exacerbation of pain.

If the lesion is located in the dorsal spine, girdle pains or a weakness in the legs may appear. If it is located in the lumbar spine, it may cause bladder or intestinal symptoms. The lesion is a mass of hard consistency; it is not fluctuating or pulsating and is attached to a bony structure.

Punch Biopsy

Punch biopsy may give discouraging results as it will generally draw pure blood.

RADIOLOGICAL CONSIDERATIONS

In the long bones the diaphyseal end of the shaft is affected and not the epiphysis. Dahlin et al,[28] however, point out that in adults the lesion may invade the epiphysis, but never the articular cartilage. The lesion is cystic, distended, with a soap bubble appearance; it is usually excentric and involves only part of the width of the bone.

In the flat bones the cyst may involve the whole width of the bone and give an elongated fusiform and almost symmetrical expansion.

The greater diameter of the tumour is usually in the long axis of the bone. It usually measures about 7cm. or more in diameter. The cortex of the bone is often destroyed and the lesion is limited at its periphery by a thin shell of periosteal new bone. The mass is semi-opaque and shows a honeycombed appearance with small trabeculae, the result of new bone formation. Subsequent films will show an increase in size of the lesion and a tendency to form new bone. This may explain the erroneous interpretation of osteogenic sarcoma because of the destruction and new bone formation.

The radiological diagnosis is not always an easy task and may even be impossible in some cases, particularly in the vertebrae. At the Mayo Clinic, Dahlin et al[28] conceded that in about 16 of a series of 26 cases the diagnosis could have been made with reasonable certainty prior to operation. However, before their present experience, only two of these tumours were diagnosed correctly on the films. In one-third of the cases the diagnosis was giant cell tumour. In the other cases, diagnoses included osteogenic sarcoma, bone cyst, hemangioma, osteochrondoma, Ewing's tumour, etc.

ANATOMICAL-PATHOLOGICAL CONSIDERATIONS

Macroscopic appearance:

If the diagnosis can not be made clinically and radiologically with accuracy, a biopsy must be performed. At operation the surgeon is impressed by the capsule which is rather rigid and extremely thin. This capsule lines a tumorous mass of a bluish colour. Once the capsule has been opened, one encounters a loculated cavity containing fluid blood and a soft brownish tissue. Blood oozes from its wall. The soft tissue inside the mass forms a brownish-red lattice adhering to the cyst wall. The blood circulation appears sluggish. No blood clots are seen and the blood in the cavity seems to come from a circulation which is continually drained and renewed.

Microscopic appearance:

Histologically, the lesion consists of vascular and connective tissues interspersed with blood lacunae of variable size. Lichtenstein compares this tissue to a sponge, the permeating spaces corresponding to greatly dilated and communicating vascular channels, the inter-vascular tissue being represented by a porous lattice. This lattice is richly vascularized and consists fundamentally of connective tissue.

Thus there are two important features in diagnosis: the presence of blood channels and cavernous blood spaces, and the histological pattern of the intermediary vascular and connective tissue. (Figs. 4,6,7,8,9.)

The intermediate vascular and connective tissue is well vascularized by dilated capillaries. The inter-lucunar septa show hemorrhagic foci in various processes of organization and these foci are sometimes in direct relationship with the cavernous vascular system. There are also a variable number of atypical giant cells in this septal tissue. These giant cells, however, are not predominant. These multinucleated cells appear to be smaller than the giant cells of a typical giant cell tumour. The nuclei are smaller and less numerous, often totalling five or six. (Fig. 8.)

The connective tissue also contains macrophages with hemosiderin pigmentation. These macrophages are related to previous tissue hemorrhages. These hemorrhagic foci produce scarring by progressive collagen formation. A constant and often predominant characteristic is the presence, in the midst of these connective tissue trabeculae, of a primitive bone metaplasia, with formation of osteoid tissue (Fig. 7) in which the bone trabeculae have a tendency to calcify readily but always in an atypical fashion (Figs. 8,9). The newly-formed bone trabeculae are surrounded by osteoblasts while the osteoclasts in Howship's lacunae bear witness to the process of resorption and remodelling (Fig. 9). This bone metaplasia is relatively active everywhere but is most active in the immediate vicinity of the blood channels. (Fig. 6.)

Fig. 6 Case 2. Blood spaces filled with noncoagulated blood limited by large fibrous septa with partly calcified osteoid tissue. (X 90.)

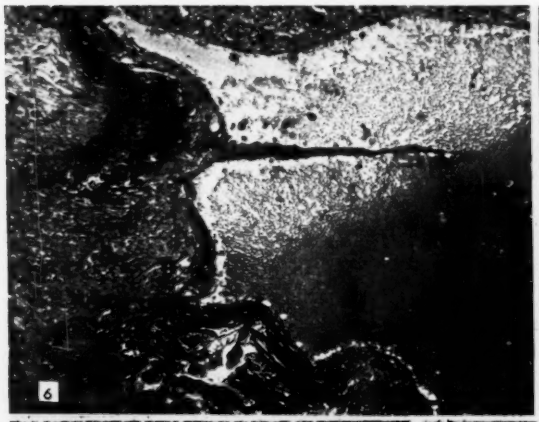
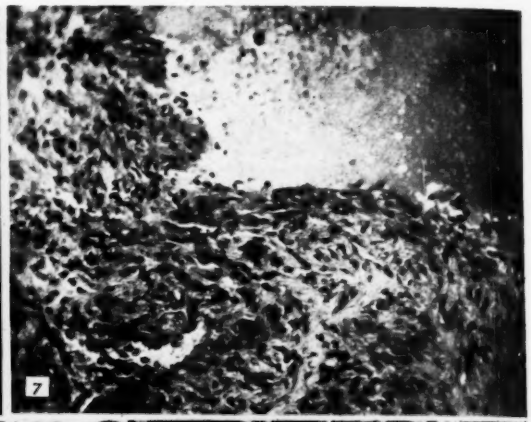


Fig. 7 Case 2. Lacunar vascular spaces showing absence of endothelium and beginning of ossification. (X 120.)



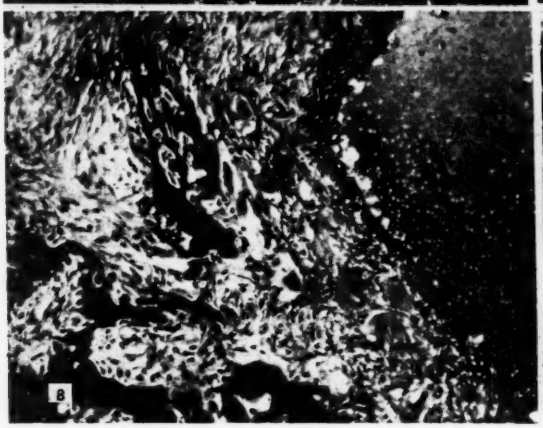


Fig. 8 Case 2. Connective tissue around cavernous space without distinct lining. Note multinucleated cells containing few nuclei at periphery. Osseous metaplasia with partial calcification. (X 120.)

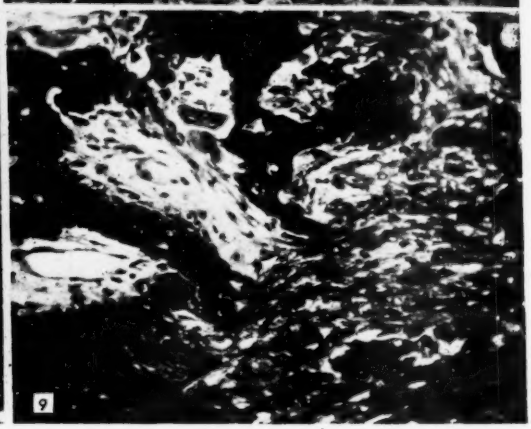


Fig. 9 Case 2. Vascular connective tissue showing active osseous metaplasia. Note newly formed osteoid tissue more or less calcified and showing osteoclasts in upper centre. (X 180.)

The vascular lacunar system of the aneurysmal bone cyst presents a haphazard pattern, being formed in one place by sinuses and communicating channels and elsewhere by greatly dilated cavernous spaces. These lacunae are not lined by a true endothelium, nor do they possess a muscular and elastic wall (Figs. 7,8). They contain, however, pure blood, so one must infer that the blood is actually circulating. As to the bony shell, it seems to be constituted by periosteal new bone. In the over-all histological picture the lesion of aneurysmal bone cyst has certainly no character of malignancy. Furthermore, it does not appear to be a true neoplasm.

PATHOGENESIS

The apparent confusion of terminology in description of aneurysmal bone cyst is due to the present lack of knowledge of the exact pathogenesis of this lesion. Synonyms include: subperiostal giant cell tumour, subperiostal hematoma and angiomatous bone cyst.

In considering pathogenesis, one should first attempt to decide whether the lesion is a true neoplasm, an angioma or a giant cell tumour.

Most writers do not accept the opinion of Hadders and Oterdoom that the aneurysmal bone cyst represents a cavernous angioma. Taylor[33] agrees with this opinion. The assertion that the sanguinous spaces are bordered by endothelium is not confirmed by the other writers. On the contrary, they all state that endothelium is absent. In true angioma of bone, capillaries are lined by an endothelium and the connective tissue septa do not show bony metaplasia with new formation of os-

TABLE III

	Aneurysmal Bone Cyst	Giant-cell Tumour
Age	Less than 20	Over 20
Site	Diaphysis; excentric; subperiosteal	Epiphysis Endosteal
Histology	Cavernous blood spaces. Few giant cells. Bony metaplasia.	Small stromal cells. Numerous giant cells.
Evolution and prognosis	No recurrence. No malignant changes; may heal even after incomplete removal.	10-20% recurrence. Sarcomatous changes possible.

teoid tissue and atypical bone trabeculae. It is difficult, therefore, to understand this concept of angiomatous bone cyst.

There is much evidence against considering this lesion to be a giant cell tumour. For instance, the age of the patient, the evolution of the lesion, the treatment, the prognosis, the localization and the histo-pathological aspects.

The following are important points in differentiating aneurysmal bone cyst from giant cell tumour.

It seems evident that the aneurysmal bone cyst is neither an angioma nor a giant cell tumour. Geschickter and Copeland,[22] who consider the aneurysmal bone cyst to be a subperiosteal giant cell tumour, give an explanation of the pathogenesis which rules out a neoplastic process. They believe that the trauma followed by hemorrhage and periosteal separation with a subperiosteal reaction, represents the initial process of the lesion. Within the cortex, the hemorrhage produces a disturbance of the vascular bed; within the periosteum it produces a reaction of healing. The excessive osteoclasia due to trauma rapidly disappears. Alternatively, an ossifying periostitis may develop.

This last observation is not exact if one studies, as we did, a considerable number of aneurysmal bone cysts.

As for the claim that aneurysmal bone cyst may represent a traumatic complication of a pre-existing giant cell tumour, the objections already stated (see Table III) are always pertinent.

Therefore we believe with most of the writers, that the aneurysmal bone cyst has nothing in common with giant cell tumour.

Jaffe[2] doubted that the aneurysmal bone cyst was a distinct entity. In his opinion the lesion representated a "hemorrhagic blow out" in a benign pre-existing bone lesion, and the subsequent reaction destroyed all signs of the original tumour. At present there are enough observations[1,19,27,30,31] to prove that the bone was intact a short time before demonstration of the cyst. Jaffe[2] himself acknowledges his inability to prove his hypothesis with the 20 cases he reported. Furthermore, as emphasized by Lichtenstein,[1] the aneurysmal bone cyst may grow in bone where the primitive benign tumour is rare: the skull, the proximal end of the ulna, the hand and the foot. This hypothesis (and the formation of the lesion on a pre-existing neoplasm) does not explain the histological picture and in some cases the steady progression. Also, it affords no explanation of the fact that, in lesions operated upon early, not even a small vestige of the presumed benign neoplasm can be found. There are therefore strong arguments against considering the aneurysmal bone cyst as a true neoplastic process or a lesion grafted on a pre-existing neoplasm.

There are also some objections to considering the aneurysmal bone cyst as a simple subperiosteal hematoma because the lesion is not similar to an organizing hematoma. In a proven case in which the lesion increases in size after a period of observation, it is difficult to believe that this could occur in a simple hematoma.

There is finally, the hypothesis of a vascular disturbance of undetermined nature. disturbing the normal bone structure and creating a process of repair by abundant new bone formation. This is not surprising if one believes that there is an effective reactivation of the periosteum. Regarding the trauma, Mary S. Sherman's objection, previously quoted, is a strong argument against this factor. It is possible that the wound may produce a hemorrhage in a pre-existing lesion, causing an increase in size of the lesion not as yet detectable by radiography.

To summarize, most writers agree that the aneurysmal bone cyst does not represent a true neoplasm. They accept, as pathogenesis, a local vascular disturbance of the bone, the cause of which is still undetermined.

From the beginning of this discussion, we adopted the terminology of aneurysmal bone cyst, but with Jaffe's qualification of the adjective "aneurysmal." This expression describes the lesion well and we see no reason to consider it as a giant cell tumour, an angioma or a hematoma.

DIFFERENTIAL DIAGNOSIS

The capillary hemangioma of a vertebra usually presents the classical picture of heavy vertical striations. This tumour involves primarily the vertebral body, and spares the apophyseal process. Often it involves two or many adjacent vertebrae. It does not destroy the contiguous structures. The aneurysmal bone cyst less frequently often involves the vertebral body alone. It often destroys the neural arch, the apophyses and also the contiguous vertebral structures. Furthermore the aneurysmal bone cyst rarely involves more than one vertebra. It does not produce vertical striations. The hemangioma is a primary bone tumour occurring much less frequently in the long bones than in the vertebra and the calvarium. In the long bones the hemangioma may be excentric or produce a fusiform expansion of the bone, with a soap bubble or honeycombed appearance, the bony trabeculae being well marked and relatively thick.

In a few rare cases it would be almost impossible to make the radiological diagnosis between the angioma and the aneurysmal bone cyst. When the angioma is in an excentric position, it seems to us that the periphery is more lobulated than the thin shell of the aneurysmal bone cyst and the trabeculae are more coarse. The bony trabeculae may be absent in the aneurysmal bone cyst but they are always present in the angioma when the expansion of the shaft of the bone is symmetrical and fusiform. The hemangioma has also a histo-pathological appearance characteristically differing from that of aneurysmal bone cyst. (Fig. 10) Furthermore it must be kept in mind that the duration of symptoms is longer for the angioma than for the aneurysmal bone cyst.

Fibrous dysplasia or Jaffe-Lichtenstein's disease also presents a microscopic pathological picture typical enough to make a definite diagnosis. It is emphasized that in fibrous dysplasia the lesion is not cystic and not hemorrhagic. One sometimes sees in the microscopic slides, microcysts made by small lacunae filled up with blood and showing fibrous septa; multinuclear cells may be seen. The microcysts are the result of degeneration of myxoid tissue. This is a very different appearance from the channels of the aneurysmal bone cyst. (Fig. 11)

The lesion of fibrous dysplasia may be monostotic or polyostotic. In 20% of cases it is monostotic. The interpretation of the X-ray appearance in most of the cases will not present any difficulty. A skeletal survey must always be made when one thinks of fibrous dysplasia. If it reveals a polyostotic lesion, the aneurysmal bone cyst, of course, should not be considered. But monostotic fibrous dysplasia in a long bone, when well limited and excentric, with a slight distention of the cortex, is almost impossible to diagnose with certainty on the films alone and a biopsy must be done. The same problem exists for some rare lesions of the ribs, clavicle and bones of the skull. However, it must be emphasized that the aneurysmal bone cyst is very rare in these bones, but fibrous dysplasia is more frequently encountered. In the ribs myeloma, enchondroma of chondromyxoid fibroma should be considered. Nevertheless, fibrous dysplasia is unlikely to produce a picture as lobulated and expanded as that of aneurysmal bone cyst.

The ossifying or osteogenic fibroma,[39,40] outside the skull, is a very rare benign bone tumour. A considerable number of these osteogenic fibromas are located in the spine. Consequently this tumour may present a problem of differential diagnosis. Like the aneurysmal bone cyst, it involves the neural arch and spinous process rather than the vertebral body. The osteogenic fibroma may sometimes produce a picture of bone destruction involving the neighbouring vertebral structures. Lichtenstein described an osteogenic fibroma of the spinous process of a vertebra which, on the films, would have shown a picture of bone destruction and expansion of the cortex comparable to the one seen in aneurysmal bone cyst. Nevertheless, in our experience and that of Golding and Sissons,[37] the lesion of osteogenic fibroma is usually central and less expanded, and does not present the finding of an excessively bulging mass as in aneurysmal bone cyst.

From the microscopic point of view, osteogenic fibroma is a solid tumour which offers some analogy with osteoid osteoma (Fig. 12). An erroneous interpretation is almost impossible with representative slides.

The giant cell tumour of bone may present a differential diagnostic problem. The main difficulty is very likely due to the tendency to classify in the group of giant cell tumours, *all* the bone lesions in which giant cells are found. Many "variants" of the true giant cell tumour have been created. Usually the only thing which these have in common is the fact that they show multinuclear cells resembling osteoclasts. The opinion of Lichtenstein[38] with regard to the problem of diagnosis and treatment of giant cell tumours is still a pertinent subject for discussion. Everyone knows the remarkable work of Jaffe and Lichtenstein regarding the identification of a great number of benign bone tumours; chondromyxoid fibroma, osteogenic fibroma, non ossifying fibroma, benign chondroblastoma, etc. But all these tumours had already been considered as giant cell tumours in spite of the multiple

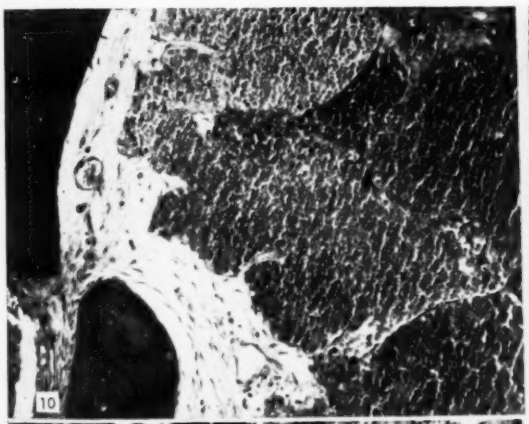
descriptive terms used in the publications: xanthic, fuso-cellular, ossifying, chondroid and chondromatous. It seems to be the same in the case of aneurysmal bone cyst which some writers call an atypical subperiosteal giant cell tumour.

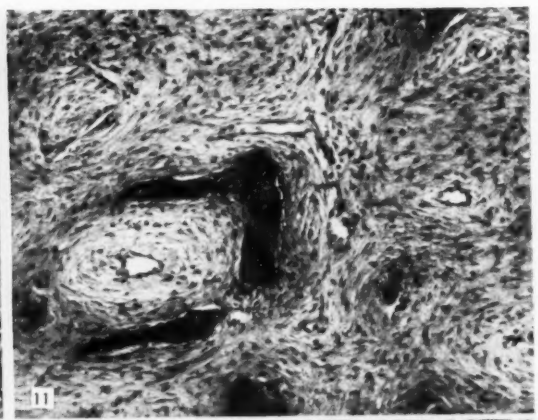
Regarding the localization, let us consider the vertebrae and the long bones. Does the true giant cell tumour really occur in the vertebrae? Dahlin et al[28] state that, out of 100 giant cell tumours observed at the Mayo Clinic, none was located in the vertebrae with the exception of the sacrum. In the publication of Mayerding,[39] not a single giant cell tumour was reported in the vertebra from a series of 40 cases. Hamsa and Campbell,[40] in a review of the literature, quoted three cases from Coley and two from Geschickter and Copeland as the only cases of giant cell tumours reported in the vertebrae. It is also emphasized that Coley was aware that his diagnosis was not certain. In the two cases reported by Hamsa and Campbell, no microphoto is reproduced and furthermore the histo-pathological description gives reasonable doubt as to the diagnosis. The patients were 6 and 14 years' old. A biopsy was done and both patients received X-ray therapy. In both cases no recurrence was observed after 17 years and 10 years, respectively. We already know that the aneurysmal bone cyst is found in a great percentage of cases in the vertebrae.

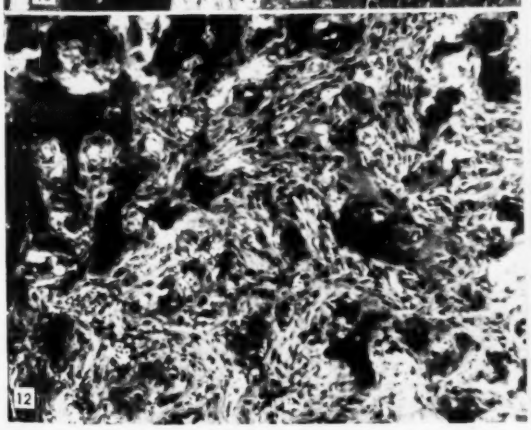
In the long bones, the true giant cell tumour is located in the epiphysis while the aneurysmal bone cyst usually involves the diaphysis. In the case of older adults diagnosis will be more difficult because, in some

Fig. 10 **Hemangioma.** The cavernous capillaries are bordered by a flat endothelium forming a wall between two dilated capillaries. (X 120.)

Fig. 11 **Fibrous dysplasia.** Vascular connective tissue showing a vague "whirling" with newly formed, atypical osteoid tissue around blood vessels. (X 190.)







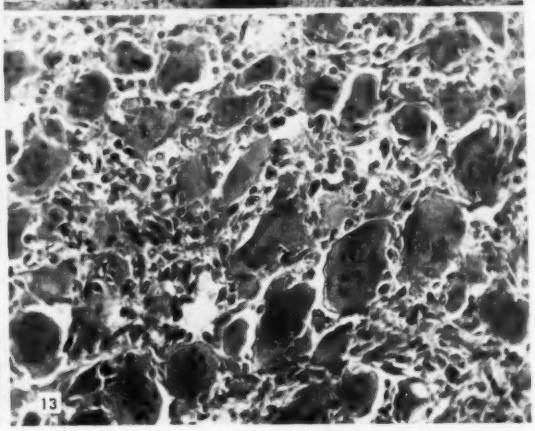


Fig. 12 **Osteogenic or ossifying fibroma.** Osteoid tissue formed by osteoblastic metaplasia of connective tissue. Irregular and atypical calcification. (X 120.)

Fig. 13 **Giant cell tumour.** Small cells and multinucleated cells with very little collagen tissue. The multinucleated cells are numerous, well distributed and contain a great number of nuclei in their centre. (X 180.)

cases, the lesions will involve the epiphysis. In flat bones, where the aneurysmal bone cyst may be seen, the true giant cell tumour is almost unknown. Nevertheless, pathological study may in some cases provide the only certain differential diagnosis between the giant cell tumour and the aneurysmal bone cyst.

It is emphasized that the aneurysmal bone cyst has an excellent prognosis and may heal completely even after an incomplete resection. On the contrary, the giant cell tumour recurs in about 10% of cases with possibility of sarcomatous changes.

From the histo-pathological point of view in the true giant cell tumour, multinuclear cells are numerous (Fig. 14). But the multinuclear cell is not the only criterion in establishing the diagnosis. Small cells or stromal cells, as called by the English writers, are the fundamental cellular element and a point of great importance in establishing the diagnosis. On the other hand, a rapid ossification in a presumed giant cell tumour must cast a serious doubt on the validity of the diagnosis. The same is also true when the tissue includes abundant collagen. In the aneurysmal bone cyst, the multinuclear cells are small and contain a few nuclei. They are less numerous and less uniformly distributed than is the case in a typical giant cell tumour. They are located in the intervascular septa, the areas of bone destruction and new bone formation in the hemorrhagic regions and especially at the periphery of the vascular lacunae where the metaplastic activity of the bone is more intense. In the typical giant cell tumour, the multinucleated cells, as already mentioned, are abundant and larger. The nuclei, well centered in the cells, are very numerous, usually more than 15 in number.

The aneurysmal bone cyst may sometimes be difficult to diagnose but usually the roentgenological and histo-pathological pictures are typical enough to rule out any other possibility.

SUMMARY AND CONCLUSIONS

1. Two cases of aneurysmal bone cyst are reported. The publications on this subject have been reviewed.
2. Aneurysmal bone cysts represent about 1% of all bone tumours.
3. Study of the localization reveals that the long bones and the lower limbs are most often affected. In the vertebrae the incidence is about 25% of the total.
4. The average age reported in 66 cases is 17.9 years and there seems to be no predilection for either sex.
5. The duration of symptoms analyzed in 58 cases is 3 months.
6. A positive history of trauma was ascertained in about 50% of cases.
7. The clinical, roentgenological and histopathological aspects have been discussed. These findings establish the aneurysmal bone cyst as a distinct pathological entity.
8. The writers seem to agree on some points of the pathogenesis. There is no real neoplastic process involved and the lesion appears to be related to a local disturbance of the bony blood supply. The cause of it is still unknown.
9. In the differential diagnosis, primary bone angioma, dysplasia or Jaffe-Lichtenstein's disease, osteogenic fibroma, giant cell tumour and solitary bone cyst must be considered.
10. We have adopted the expression "aneurysmal bone cyst" with Jaffe's restrictions on the meaning given to the word "aneurysmal." There is no reason to consider this lesion as a giant cell tumour, an angioma or a hematoma.

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A CONSIDERATION OF THE EQUIVALENT CIRCLE METHOD OF CALCULATING DEPTH DOSES FOR RECTANGULAR X-RAY FIELDS*

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Central axis depth dose data for circular fields have been measured by numerous investigators for a variety of irradiation conditions. These data were collected originally in the survey published by Mayneord and Lamerton[1] in 1941. The more recent survey contained in Supplement No. 5 of the British Journal of Radiology[2] is a revision and extension of Mayneord and Lamerton's percentage depth dose tables. Also, new surface backscatter measurements for circular fields have been published recently by Johns, Hunt and Fedoruk[3] and by Greening[4]. In theory, at least, it is possible from these data to calculate the dose at any point in a tissue-equivalent medium irradiated by X-rays, whatever the shape of the field.

The graphical methods suggested by Clarkson[5] and by Tranter[6] are applicable to fields of any shape, regular or irregular, and are subject only to the error inherent in replacing an integration by the summation of a finite number of terms but, in application, are laborious.

Meredith and Neary[7] have presented an analytic method for circles, squares and rectangles which has been widely used. This method, also, is time-consuming and suffers from the fact that their tables of empirical constants fit only Mayneord and Lamerton's central axis depth dose tables from which they are derived and must be re-evaluated if different central axis depth dose data are to be used.**

For square and rectangular fields the "equivalent circle method" proposed by Jones[8] and by Day[9] is simplest in application. This method assumes that for every square or rectangular field there exists a circular field for which the central axis depth doses (i.e., total doses per 100 "r" air dose at the surface) are identical with those for the square or rectangular field. Knowing the radius (or area) of the equivalent circle, the central axis depth doses for a rectangular field may be read directly from curves for circular fields. Since the depth dose at any point inside or outside a rectangular field can be determined as the sum or difference of central axis depth doses for rectangular fields,[7,9] the equivalent circle method furnishes a complete solution for rectangular fields.

Tables of equivalent radii in use to date have been prepared from experimental data or from data calculated by Meredith and Neary's method and cannot be assumed a priori to apply to conditions other than those for which the data were determined.

In this paper a more general approach has been made to the problem of equivalent diameters. The method shows that in the transition from circular to elongated rectangular fields the purely geometrical aspect is dominant and the conditions of irradiation, i.e., focus-skin distance, half-value layer and depth appear only in second and third order terms. Further, compromise values of the constants in the second and third order terms have been adopted which appear to be sufficiently accurate for practical purposes over a wide range of irradiation conditions. It is thus possible to set up a single equation which yields the radius of the circular field which is equivalent with respect to central axis depth doses to any given rectangular field.

Formal Statement of Equivalent Circle Method

For the purposes of this paper it is convenient to describe a rectangular field by the parameters R_0 and E where R_0 is the radius of a circular field of the same area as the rectangle and E is the "elongation", i.e., the ratio of the length to the width of the rectangle. If the length is A and width is B, R_0 and E are obviously related to A and B by the equations

$$R_0 = \sqrt{\frac{AB}{\pi}} \text{ and } E = \frac{A}{B} \quad \ldots\ldots\ldots\ldots (1)$$

Let D(R) denote the central axis depth dose at any specified depth for a circular field of radius R and let $D(R_0, E)$ denote the corresponding central axis depth dose for a rectangular field described by R_0 and E. Then, the equivalent radius (i.e., equivalent with respect to central axis depth doses) of the rectangular field is defined as YR_0 where

$$D(YR_0) = D(R_0, E) \quad \ldots\ldots\ldots\ldots (2)$$

*Presented at Annual Meeting, The Canadian Association of Radiologists, January 11, 1955, Ottawa.

**A re-evaluation of the Meredith & Neary constants based on the depth dose tables of Supplement No. 5, British Journal of Radiology, has just been published by R. J. Horsley & N. Aspin. "New Values of Constants for Use in Calculating Isodose Curves by the Method of Meredith & Neary", British Journal of Radiology, 1956, XXIX, 625-627.

The fundamental problem of the equivalent circle method is to find the value of Y for any given set of conditions. In general, Y may be expected to be a function of R_o, E, depth, half value layer and F.S.D., i.e., a function of all the variables which determine the central axis depth doses. The equivalent circle concept is useful, however, only if it is possible to obtain a relatively simple relationship between Y and the different variables on which it may depend.

General Approach to the Fundamental Problem

Following Clarkson's method we may state formally for any rectangle

$$D(R_o,E) = \frac{1}{2\pi}\int_o^{2\pi} D_R(\theta)\, d\theta \quad \ldots\ldots(3)$$

where $D_R(\theta)$ is identical with D(R) as defined in the preceding section but the new notation implies that the radius R has been expressed as a function of the aximuth angle θ. The relationships between R and θ for a rectangle are obvious from figure 1. For $\theta < \cot^{-1}E$,

$$R = \frac{R_o}{2}\sqrt{\pi E}\,\sec\theta \quad \ldots\ldots(4)$$

and, for $\cot^{-1} E < \theta < \pi/2$,

$$R = \frac{R_o}{2}\sqrt{\frac{\pi}{E}}\,\csc\theta \quad \ldots\ldots(5)$$

If we have an analytic expression for D(R) as a function of R we can use equations (4) and (5) to get an analytic expression for $D_R(\theta)$ as a function of θ. Further, we should be able to evaluate equation (3) analytically or graphically to find the required central axis depth dose $D(R_o,E)$ for the rectangle.

We can always express D(R) as a Taylor's series, i.e.,

$$D(R) = D(R_o) + K(R - R_o) + L(R - R_o)^2 + \ldots\ldots(6)$$

where

$$K = \left\{\frac{dD(R)}{dR}\right\}_{R=R_o} \ldots(7) \text{ and } L = \frac{1}{2}\left\{\frac{d^2D(R)}{dR^2}\right\}_{R=R_o} \ldots(8)$$

Using equations (4), (5) and (6) we can evaluate the integral of equation (3). For the purpose we rewrite the integral as

$$D(R_o,E) = \frac{2}{\pi}\int_o^{\cot^{-1}E} D_R(\theta)\, d\theta + \frac{2}{\pi}\int_{\cot^{-1}E}^{\pi/2} D_R(\theta)\, d\theta \ldots\ldots(9)$$

where, in the first integral, we use for $D_R(\theta)$ the expression obtained by substituting equation (4) into equation (6) and, in the second integral, we substitute equation (5) into (6) to get the expression for $D_R(\theta)$. Carrying out the integration we get

$$D(R_o,E) = D(R_o) - KR_o(1-Z) + 2LR_o^2(1-Z) \ldots\ldots(10)$$

where

$$Z = \frac{1}{\sqrt{\pi}}\left\{\sqrt{E}\ln\frac{E}{\sqrt{1+E^2}-1} + \frac{1}{\sqrt{E}}\ln\frac{1}{\sqrt{1+E^2}-E}\right\} \ldots\ldots(11)$$

It will be noted that Z is a function of the shape of the field only but K and L in equation (10) depend on the scatter curve and, therefore, are functions of the field size and the irradiation conditions.

We now seek a correction factor Y such that

$$D(YR_o) = D(R_o,E) \ldots\ldots(2)$$

as stated in defining the concept of equivalent circle. From equation (6)

$$D(YR_o) = D(R_o) + KR_o(Y-1) + LR_o^2(Y-1)^2 \ldots\ldots(12)$$

Equations (10) and (12) are identical to and including third power terms in R_o if we put

$$Y = Z + \frac{L}{K}(1-Z^2)\,R_o + 2\left(\frac{L}{K}\right)^2(1-Z)(1-Z^2)\,R_o^2 \ldots\ldots(13)$$

Thus, the first order term in the expression for Y depends only on the shape factor E but the second and third order terms depend also on the size of the field and, through L/K, on the shape of the scatter curve and, therefore, on the depth and irradiation conditions.

Practical Approximation

Except for very elongated fields the value of Z as given by equation (11) approaches unity and the second and third terms of equation (13) become small compared with the first term. Under this circumstance we may use a very approximate value of L/K and yet hope to get acceptable values of Y. In practice, $L/K = -0.0707$ gives satisfactory values of Y over a wide range of field sizes and elongations and a wide range of treatment conditions. Substituting this value in equation (13) we have

$$Y = Z - 0.0707(1-Z^2)\,R_o + 0.01(1-Z)(1-Z^2)\,R_o^2 \quad (14)$$

i.e., the correction factor becomes a function of the size and shape of the rectangular field but is independent of the irradiation conditions.

The approximation of equation (14) can be justified only by showing that the values of Y obtained from this equation when substituded in equation (2) lead to depth doses for rectangular fields which are in satisfactory agreement with experimental values or with values calculated by one of the accepted methods. It will be shown in a later section that for radiation qualities ranging from a half-value layer of 0.5 mm. Cu to Cobalt 60 radiation, equation (14) does in fact yield depth dose data for rectangular fields of sufficient accuracy for practical purposes.

Application

In application, Y may be calculated once for all from equation (14) for the complete range of values of E and R_0 which will be encountered in practice. The authors have carried out the calculations for values of E ranging from 1 to 10 and for values of R_0 from 0 to 20 cm.

Y having been calculated, it is convenient to present the results in graphical form plotting Y vs. E with R_0 as parameter. Illustrative curves are shown in figure 2. For practical application, however, figure 2 is not suitable as the scales should be expanded to permit reading Y with at least three-figure accuracy. If curves are plotted for integral values of R_0, Y for non-integral values may be obtained readily by interpolation since, except for the largest values of R_0, the interpolation is almost linear.

While it is possible to read Y directly for each rectangular field encountered from curves similar to those of figure 2, it is more economical to tabulate once for all the equivalent radii of commonly used fields. This has been done in Table I. This table is similar to that given by Day[9]; it will be noted that the equivalent radii are in good agreement with Day's values.

Practical Test of Approximation

It remains to determine by trial the range of irradiation conditions for which equation (14) is a satisfactory approximation. Total doses per 100 r air dose as determined by the method of this article are compared in Table II with those determined by Clarkson's method for several depths and for a variety of field sizes and irradiation conditions. The values in both cases are based on total dose curves for circular fields determined from John's back-scatter values and the percentage depth dose tables of Supplement No. 5, British Journal of Radiology (Tables 3A to 3H). In Table III the total skin doses of Table II (or, for Cobalt 60, the total maximum doses) have been converted to surface back-scatter factors and the total depth doses have been converted to percentage depth doses.

The critical tests of the equivalent circle method are obviously the results obtained for the largest fields and for the largest values of the elongation E since it is for these cases that the second and third terms of equation (14) become most important. Unfortunately, it is for just these cases that Clarkson's method is least accurate since we must extrapolate the published tables to find the contributions of segments for which the radius is greater than 11.3 cm. Very elongated fields of large area are encountered, however, only when we attempt to calculate depth doses at points in a field which are remote from the axis, i.e., near or outside the geometrical edge of the field. With this in mind, it appears that the results obtained by the equivalent circle method and by Clarkson's method are in satisfactory agreement for all the conditions shown in Tables II and III.

It is safe to assume that the values of Y calculated from equation (14) can be used to determine equivalent radii for still harder radiations than that obtained from a Cobalt 60 source since for harder radiations scatter becomes less important and, therefore, the value of the equivalent radius less critical. The authors have not investigated the applicability of equation (14) to radiations for which the half-value layer is less than 0.5 mm. Cu and no assumptions can be made about the extension to softer radiations without adequate test. Even though the equivalent radii determined from equation (14) may prove unsatisfactory for softer radiations, no doubt satisfactory values of equivalent radii can be found by using a different value of L/K in equation (13). However, as has already been pointed out, the method loses much of its convenience if different equivalent radii must be used for different irradiation conditions.

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RADIOLOGIC DIAGNOSIS OF RENAL TUMOURS BY RENAL ANGIOGRAPHY*

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During the past five years renal angiograms have been performed on the majority of cases of renal tumours in the Los Angeles County Harbor General Hospital. The authors have been impressed with the contribution of this method of examination to the diagnosis in selected cases. This presentation outlines the concepts and impressions gained from our experiences and from the available literature.

Technique

The cases considered have all, with one exception, been performed by the translumbar method as described by Walter and Goodwin,[18] and have been done under the direction of the latter. The reader is referred to their publication for details. The actual puncture has been performed by a variety of residents with consistent, although not uniform, success. In a few cases radiographs have been made with the Sanchez-Perez rapid cassette changer, but the majority have been done with a conventional radiographic unit.

We are impressed that rapid serial exposures, millisecond (1/1000 second) exposures[2] improvements in contrast media, and catheterization techniques[3,11,15] all merit continued investigation and may very well improve the diagnostic accuracy and safety of the procedure.

Fig. I Retrograde pyelogram showing left renal mass. Case continued in Fig. II.

Risk

One hundred and thirty-seven aortograms have been performed for a variety of conditions without fatality. Our most serious complication was a pyogenic osteomyelitis of the lumbar spine. This developed following aortography and this procedure must be suspected as the probable cause since no other reasons were found. Others have experienced fatalities or severe complications.[6,5,10,14] One large malpractice award was recently made, in San Francisco, to a patient who sustained a transverse myelitis.[13]

The risk can be reduced by eliminating patients with gross impairments of renal function. A test injection is invaluable in eliminating the possibility of injection of large quantities of concentrated contrast medium into one renal artery. Reduction in quantity of contrast substance is necessary with high aortic obstructions.[10]

Roentgen Appearance of Tumour Vessels

Tumour vessels are characterized by a disordered abundance. A variety of patterns may be seen. The normal arborization and progressive diminution in caliber from the main trunks to the terminal small arteries is replaced by variable degrees of abnormality. Usually there is an increase in vascularization. The usual smooth even contour of the approximately parallel vessel walls is replaced by irregular margins. Sometimes the outline is sharp; however, more often the vessel outline is vague and indistinct. Orderly branching is usually replaced by numerous vessels with haphazard branching and abnormal communications. The vessels show irregular dilatations (puddling or laking of contrast media

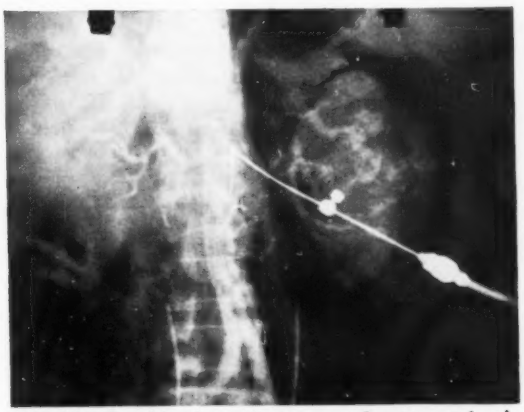

Fig. II Combined aortogram and presacral air study shows large left renal mass, with upper two thirds of the kidney occupied by a bizarre, coarse irregular, and distorted vascular pattern characteristic of renal cortical carcinoma. The diagnosis was confirmed pathologically.

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occurs in these dilatations). Vessels may end in apparently blind blunted pouches (tufting). The predominant vascular pattern may be made up of fine rather vaguely outlined vascular structures, or in our experience, less often by large coarse fairly well defined vessels (Fig. 2). The vascular patterns may be difficult to distinguish from colonic content and other artefacts. This is particularly true when one tries to identify tumour vessel patterns in the renal vein extensions. A preliminary film for base line comparison is very helpful in evaluating such minor variations. A "tumour stain" may be seen in the nephrogram.

In most cases tumour vessels are identifiable without difficulty. Occasionally the distinction between abnormal and normal vessels is difficult. The reasons for this difficulty appear to be as follows: —

1. The involved vessels may be quite small and minor irregularities in such vessels are easily overlooked.
2. The tumour bed may occupy a very small area and be relatively inconspicuous.
3. Motion may result in a blurred image of the vessels. Among the sources of such motion are:
   a. The patient (respiration, tremor, failure to cooperate, etc.).
   b. Motion secondary to contraction and relaxation of the small vessels.
   c. Vibration of x-ray equipment especially rapid plate changers and x-ray tubes.

   Very short exposures such as advocated by Dotter[2] for angiocardiography should eliminate this source of error.
4. Rapid multiple serial exposures may demonstrate the typical pathologic vascular pattern on only one or two frames. The unfailing demonstration of pathologic vascularity by single film technique is not possible. The ideal arrangement would include provision for rapid serial exposures. The optimum number of exposures to be made in one second remains to be settled. We estimate that such expensive equipment would improve results by 2 to 5 percent.
5. Tortuous vessels and area of hemorrhage may in our experience produce an appearance which can be confused with some tumour vessels. Careful attention to the detail of the vascular pattern should make the differentiation between tortuous vessels and tumour vessels easy.

Significance of Tumour Vessels

About nine cortical carcinomas in ten will show tumour vessels.[19] The ones failing to show tumour vessels do so because of necrosis,[12] avascularity,[20] cystic degeneration,[4] and failure to make the exposure at the time of their visualization. Aside from one liposarcoma,[16] we know of no renal tumours other than cortical carcinomas that show tumour vessels. Pelvic carcinomata, some sarcomata, metastatic carcinomata and benign adenomata[9] thus far have not demonstrated tumour vessels.

Radiologic Findings In Specific Indications

1. With negative urograms and pyelograms.
   a. Löfgren[8] has demonstrated a small one centimeter tumour with negative pyelograms.
   b. Hemangiomas may show very scant or no findings on pyelography. It is anticipated that these lesions should show typical angiographic findings.
2. With equivocal pyelographic findings.
   a. The pyelographic findings may warrant the suspicion that a renal tumour is present, but are not sufficiently abnormal to permit a positive diagnosis. In such a case the demonstration of tumour vessels establishes the presence of

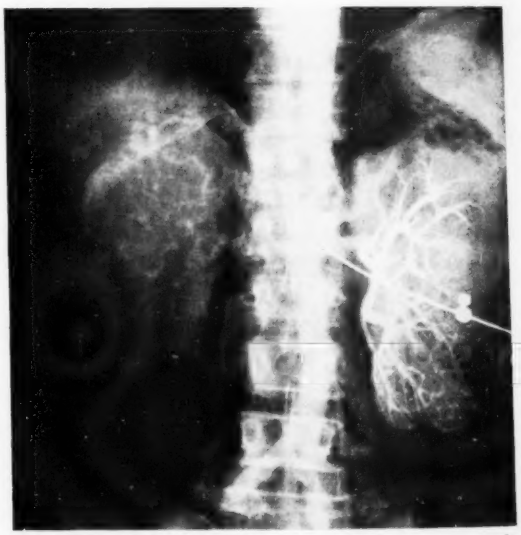

Fig. III This patient presented with hyperpyrexia and bilateral renal masses were discovered on physical examination. Retrograde pyelograms published elsewhere[21] were interpreted as showing polycystic disease. Aortogram shows a widened cortex of left kidney with apparent displacement of vessels. This was considered to support the pyelographic impression of polycystic kidney. The significance of the irregular vascularity in the lower pole was not appreciated until biopsy at another hospital disclosed a carcinoma. Patient died following surgery and post mortem was refused. In retrospect aortograms should have been interpreted as showing both polycystic disease and carcinoma.

a renal cortical tumour. The absence of such vessels, however, does not permit the exclusion of such a lesion, but substantially reduces its probability.

We had a case with a 2 cm. tumour[21] which showed a small pyelographic defect. After nephrectomy the resident in pathology split the kidney and informed us he could find no tumour. After review of our radiographs which showed characteristic tumour vessels, he made further sections and the tumour was easily located.

b. A polycystic kidney complicated by cortical carcinoma may be demonstrated by the avascular wide cortex and vessel displacements of the polycystic disease and the tumour vessels of the carcinoma[21] (Fig. 3).

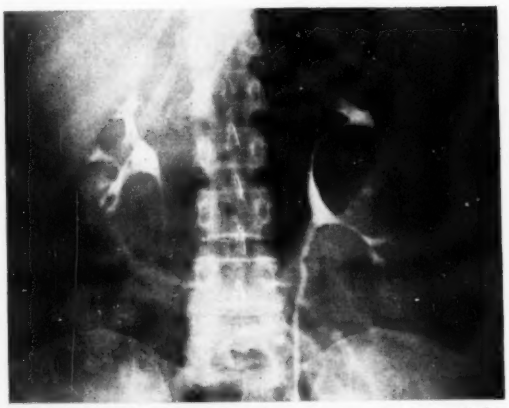

Fig. IV Pyelogram showing large extra pelvic mass. Case continued in Fig. V.

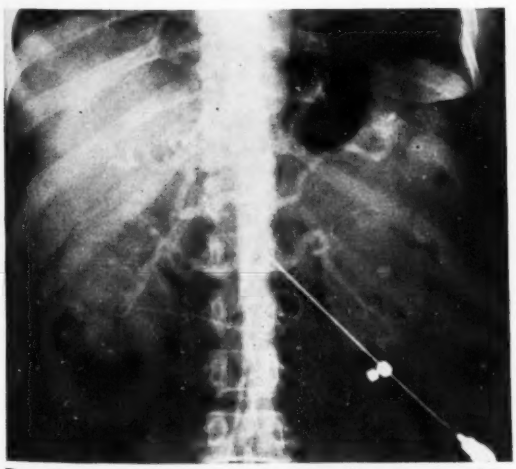

Fig. V Aortogram showing avascular area in midportion of left kidney. The centrally located density is a calculus. The appearance simulates cyst or avascular tumour. At surgery a renal abscess was found.

c. We have encountered several cases of hydronephrosis associated with renal neoplasia.[21] In these cases the presence of tumour was not clearly shown by the pyelograms. Demonstration of tumour vessels in such cases is conclusive.

3. With renal space-occupying lesions (Figs. 1, 2, 4 and 5).
   a. About nine of ten cortical carcinomata will show tumour vessels.
   b. The causes of avascular areas with displaced vessels are shown in Table I.

TABLE I

The Causes of Avascular Areas With Displaced Vessels

I.	Certain cortical carcinomata (see supra) and other renal tumours.
II.	Polycystic kidneys.
III.	Renal cysts.
IV.	Renal infections (abscesses, granulomata) See Figs. 4 and 5.
V.	Calyceal diverticula.
VI.	Extra renal masses.
VII.	Renal infarcts and hematomata.
VIII.	Impaired blood supply.
IX.	Technical. Aberrant arteries with partial injection of arterial tree.

4. Determination of extent of lesion.
   a. The extent of the tumour is no less than the vascular pattern of the neoplasm. Cystic and necrotic areas may not be demonstrated by the angiogram so the entire extent of the tumour may not be visualized.
   b. Both before surgery and by review of older cases in retrospect we have found a high correlation between linear strands of tumour vessels in the hilar area and renal vein involvement by tumour. Our experience is still very small and limited to six cases. The findings are assumed to be due to the fact that tumour thrombi in the renal veins carry with them their own arterial blood supply. It is this blood supply that shows tumour vessels.

5. Distinction between renal and extrarenal tumours.
   a. Renal outline may be clearly shown by vascular pattern or by nephrogram to be distinct from the tumour mass.
   b. The blood supply of the tumour mass may be shown to be other than renal.
   c. Certain adrenal tumours may show tumour vessels.

Indications for Renal Angiography

1. Negative urograms and pyelograms in the face of strong clinical evidence of renal neoplasm.
2. Equivocal urographic and pyelographic findings suggesting renal neoplasm.
3. Renal space occupying lesions of uncertain origin.
4. The need for evaluation of the extent of a renal tumour in order to aid in the determination of its operability or the optimum surgical approach.
5. The failure of preliminary films, urograms and pyelograms including lateral projections, presacral air injection and body section radiography to decide whether the tumour is extra or intrarenal.

Contraindications

1. The general contraindications to the use of the contrast medium, particularly impaired renal function.
2. When the diagnosis is established and the surgical management is clear.
3. When the aortic puncture must be made through severe disease such as an aneurysm.

The Differential Diagnosis of Renal Tumours and Cysts

While it is not possible for the radiologist to distinguish with absolute certainty between renal cysts and tumours a very high degree of accuracy is theoretically possible.

The presence of tumour vessels is pathognomic of a malignant tumour. Less than one third of all renal tumours will fail to show such a vascular pattern.[21]

Percutaneous puncture of the mass[7] will aid in the distinction between a cyst and a solid tumour. The smooth spherical outline of the non-neoplastic cyst (Fig. 6) is easily distinguished from the irregular mottled shadow of the solid tumour (Fig. 7). Cysts are found in association with renal carcinoma in about 7 percent of cases.[17] The probability of a renal carcinoma without a distinctive pathological vascular pattern, being associated with a renal cyst is calculated as follows[21]: — $1/3^{(a)} \times 1/14^{(b)} = 1/42$.

(a) 1/3 of renal tumours do not show tumour vessels.

(b) 1/14 of renal tumours are associated with renal cysts.

The probability of error is reduced to less than 1/42 by the following: —

1. A few cases will show pyelographic findings that are distinctive between tumour and cyst. In particular pelvic tumours will show pyelographic or ureterographic findings incompatible with a benign cyst and characteristically show no angiographic findings. Cortical tumours may also extend to the pelvis and produce an irregular filling defect.

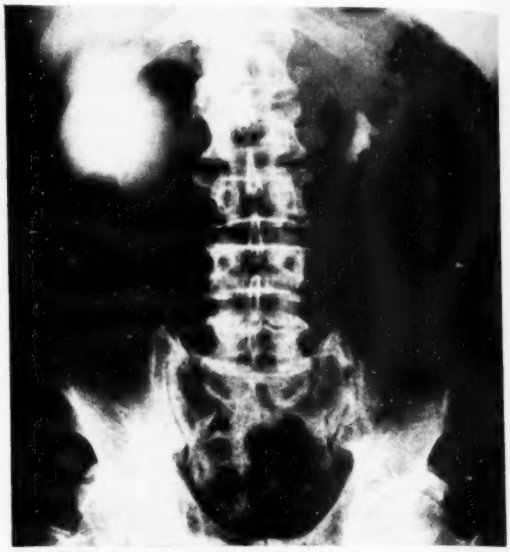

Fig. VI Percutaneous puncture of renal cyst with injection of contrast media after aspiration of cyst contents. Fluid from cyst was not sanguinous and contained no tumour cells. Smooth outline with absence of filling defects speaks for a non-neoplastic cyst. Poor general condition made exploration undesirable. Patient alive two years later with no change in renal findings.

Fig. VII Percutaneous puncture of renal mass lesion of lower pole of the left kidney. Clinical impression was renal cyst. Irregular pattern of contrast medium indicates renal tumour. Pathological diagnosis was carcinoma of the renal cortex.

2. An irregular filling defect in the contrast filled cyst should suggest a tumour.

3. The presence of tumour cells in the aspirated cyst contents is incompatible with the diagnosis of benign cyst.

4. Bloody cyst aspirate is associated with tumour in 25-35 percent of cases!

Our experience with the combined procedure of angiography, percutaneous puncture of the cysts, contrast visualization, and cyst content examination is limited and does not permit definite conclusions.

Conclusions

1. Renal angiograms are of considerable value in the diagnosis of certain renal neoplasms and should be used in selected cases.

2. Indiscriminate or routine use of renal angiography is undesirable because the hazard, although small, is significant.

3. It is anticipated that perfection of techniques, equipment, and contrast substances should in time permit a wider, safer, and more effective use of renal angiography.

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THE CANADIAN ASSOCIATION OF RADIOLOGISTS
20th ANNUAL MEETING

The 20th Annual Meeting of the Canadian Association of Radiologists will take place from Sunday, January 13th to Thursday, January 17th, in the Sheraton Mount Royal Hotel, Montreal.

Major features of this anniversary meeting will be the five-part report on $Cobalt^{60}$, addresses of welcome by His Worship, Mayor Jean Drapeau, and Dr. Marc Trudel, president of the College of Physicians and Surgeons of the Province of Quebec, the Gordon Richards Memorial lecture, and a civic reception to be held at the Chalet on beautiful St. Helen's Island.

The annual meeting of the Association will take place on Monday, January 14th, at 7.30 p.m., at which time reports will be given and officers and directors elected. The annual dinner will be on Wednesday, January 16th, at 7.30 p.m.

The $Cobalt^{60}$ report, the first 5-year compilation to be presented in the world, will include the following: Cobalt Telecurie Therapy — after 5 years — presented by T. A. Watson, M.D., Saskatoon; A $Cobalt^{60}$ Dosage Study in Oral Carcinoma — by D. H. Thomson, M.D., and Ivan H. Smith, M.D., of London, Ontario; Interim Results of $Cobalt^{60}$ Therapy — by R. J. Walton, M.B., Ch.B., and James E. Bennett, M.B., Ch.B., Winnipeg; Localization of Tumours for $Cobalt^{60}$ Circumaxial Rotation — by G. C. Catton, M.D., Ottawa; and Pre-Determined Dose Distribution and Measurement in $Cobalt^{60}$ Circumaxial Rotation — by R. O. Kornelson, M.Sc., Ottawa.

An impressive list of papers will be presented during the scientific sessions of this annual meeting.

The Association is looking forward to the largest turnout of members in its history, and sincerely hopes that members will make every effort to be present.

POSITIONS AVAILABLE

Radiologist required immediately as assistant to Director of Radiology. Well established hospital — 265 beds. Modern department. Must be eligible for certification by Royal College of Physicians and Surgeons of Canada in diagnosis and therapy. Salary basis, open to negotiation on fee-for-service basis. Age limits between 30 and 40. Write — Administrator, Sarnia General Hospital, Sarnia, Ontario, Canada.

Certified radiologist required for 100 bed hospital in growing community, salary percentage fee for service, minimum guarantee if desired, nine active doctors in practice, department fully modern, recently renovated and fully staffed. Write giving personal history, qualifications, and references to Administrator, Prince Rupert General Hospital, Prince Rupert, B. C.

In Memoriam

It is with deep regret that the Canadian Association of Radiologists records the deaths of two radiologists during 1956.

ANDRUS, Paul Morphy
April 26, 1894, London, Ontario
M.D. — University of Western Ontario, 1919

MALCOLMSON, Patrick Hamilton
April 4, 1907, Frank, Alberta
M.D. — University of Toronto, 1930.